Critical reading of science-based news reports: establishing a knowledge, skills and attitudes framework

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Abstract

A recognised aim of science education is to promote critical engagement with science in the media. Evidence would suggest that this is challenging for both teachers and pupils and that at science education does not yet adequately prepare young people for this task. Furthermore, in the absence of clear guidance as to what this means and how this may be achieved it is difficult for teachers to develop approaches and resources that address the matter and that systematically promote such critical engagement within their teaching programmes. Twenty-six individuals with recognised expertise or interest in science in the media, drawn from a range of disciplines and areas of practice, constituted a specialist panel in this study. The question this research sought to answer was 'what are the elements of knowledge, skill and attitude which underpin critical reading of science based news reports'? During in-depth individual interviews the panel were asked to explore what they considered to be essential elements of knowledge, skills and attitude which people need to enable them to respond critically to news reports with a science component. Analysis of the data revealed fourteen fundamental elements which together contribute to an individual's capacity to engage critically with science-based news. These are classified in five categories 'knowledge of science', 'knowledge of writing and language', 'knowledge about news, newspapers and journalism', 'skills' and 'attitudes'. Illustrative profiles of each category along with indicators of critical engagement are presented. The implications for curriculum planning and pedagogy are considered.

Introduction

For most people there are two sources of science knowledge. There is science received in formal settings such as school and science assimilated through numerous everyday experiences. The former spans a comparatively short period and addresses what is, for the

learner, an externally prescribed curriculum. The latter is largely composed of informal free choice experiences from both work and leisure contexts which often take in topics beyond the scope of school science, commonly touch on leading edge research and are accessed through a range of media sources prominent among which are newspapers.

Informal sources of science information, including science in the news, are recognised and valued in school science A visit to the science department in almost any secondary school in the UK is likely to uncover evidence of some past or present use of newspapers as a resource to support science instruction Principally news stories are used to underscore the links between science taught in school and science in the world beyond the classroom (Jarman & McClune 2002). They tend, however, to be seen as a supplement to the matter under consideration and to be accorded a minor role in the process of teaching and learning.

Researchers in the UK have highlighted a significant relationship between science topics in the news and science topics in the curriculum (Hutton 1996; Wellington 1991, 1993). Their work points to the potential role for science-based news media within a curriculum enhancement model of media engagement. Important as this role is, inevitably the approach is limited in its scope focusing as it does on conventional school science topics. Moreover, its success relies on the profile of science in the news at the time of teaching. Pertinent news items seldom come along just when they are needed. It is more often the case that potentially worthwhile examples of science-based news stories are either 'of the moment' and their impact diminishes as their media coverage wanes or they are not clearly linked to a particular curriculum topic.

Recent reviews of science education, however, have recognised a more purposeful reason for studying science in the media, and, in so doing, have highlighted further and more serious limitations associated with current practice in this regard. Increasingly there is a view of science-based news not only as a resource for science education but also as a focus of science education. There is a growing acknowledgement that one important aim of science

education should be to prepare students to engage with science in the contexts they will encounter in later life. This notion is often expressed in terms of promoting a critical response to science in the media and it is found in curriculum thinking in a number of countries and in statements of their curricular goals. For example, in the United Kingdom, Millar and Osborne (1998: 12) have suggested that the capability to engage critically with science-based news be promoted as a desirable outcome of a science education. Consequently, they have as one of the aims for science education that:

> 'Young people should be able to understand, and respond critically to, media reports with a science component.'

This theme has resonance internationally. In the United States 'National Science Education Standards' (National Research Council, 1996: 22) aim to promote an aptitude and ability to engage with science issues which are reported in the press

It is suggested that:

> 'Scientific literacy involves being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions.'

Similar intentions are found in curricular documents from e.g. Canada, (Council of Ministers of Education, Canada. 1997). More recently in the UK promoting a critical response to science in the media has emerged as an explicit factor of curricular revisions (Qualifications and Curriculum Authority, 2003; Council for Curriculum, Examinations and Assessment, 2003). Media literacy or media awareness has been introduced as a 'cross-curriculum dimension' or 'key element' into each subject area. In the English national curriculum for 11-14 year olds it is advocated that the curriculum should provide opportunities for students to gain 'an appreciation of how science is represented and sometimes misrepresented in the media' and in Northern Ireland (NI) students are required to:

> 'Investigate how the media … help inform the public about science and science related issues and to explore some of the strengths and limitations of these sources of information'.

The capability and aptitude to engage critically with media-based science is recognised as one among many manifestations of scientific literacy. This association stems at least in part from the view of scientific literacy which highlights the value of science for personal empowerment and civic engagement. It is assumed that the key science-based issues of the time will be aired in the press and that the news media can serve as a source of ongoing learning in science. Hence, both the use of the news media to foster scientific literacy and the desire to prepare individuals to read news articles with a science component in the development of a scientific literacy capability are complementary. They prefigure the promotion of informed involvement of individuals and communities in science-based issues having personal and social significance. Scientific literacy, science in the media and media education each support extensive literatures and are of interest to not only science educators, but also those involved in the study of science communication, media education, journalism and literacy.

Internationally the profile of media education within secondary curricula is increasing (Bazalgette, Bevort & Savino,1990). Initially it was associated with the teaching of English or as the separate subject 'Media Studies'. More recently media education under the guise of 'media awareness' or 'media literacy' is gaining a foothold across a wider subject base. This growth in media education may reflect the all-pervasive nature of media and its increasing association with personal and citizen education (Pring, 1987; Woyach, 1991). Its extensive literature, which provides a wider context for this study, addresses both the how and why issues of media education. The nature and techniques of mass media, the critical and analytical skills needed to engage with it and the personal attributes of self-confidence and critical judgement which media education seeks to engender are all explored. At the practical level, its advocates have

long promoted a cyclical view of curriculum where concepts introduced at an elementary level are later 'explained, developed and extended in increasingly sophisticated ways' within a collaborative teaching model (Duncan, B. George, J. Lalonde, P 1989; Masterman, 1985, 1992; Thoman, 1995).

Recurrent themes within the literature point to certain key concepts in media education. These include the idea that news is a representation of the world (Branston & Stafford 2003; Bromley 2004; Thoman & Jolls 2003). As Philo (1983: 135) contends:

> 'News on Television and in the press is not self-defining. News is not found or even gathered, it is made. It is a creation of a journalistic process '

From this emerges the oft-repeated tenet of media education that 'news is a construction'. Associated with this is the idea that news is not neutral it has both implicit and explicit values. News-makers may actively seek to influence the audience to guide their thoughts and at times to persuade (Galtung & Ruge, 1973; Philo, 1983; Reah, 2002).

Issues around news production are also considered. News stories are generated within certain constraints and in line with codes and conventions which affect its production and transmission. Journalists use what Lewis (2003) calls a 'repertoire of familiar elements' to attract the reader, surfer, listener or viewer and to make news accessible. Paradoxically, it is adherence to these conventions and constraints that sometimes results in censure of news outlets with, for example, criticisms of superficiality and sensationalism in the news (Keeble, 2001; Peters, 1999; Priest 1999)

The idea of media audience is also addressed and within this theme a number of issues emerge. Consideration of the impact of news on the audience is often noted, however, the impact of the audience on the media receives less consideration. In the former issues such as the nature and use of language, the journalist's view of objectivity and the access to and presentation of sources are all noteworthy. The audience, however, cannot be taken for

granted; news media must compete for their attention. Consequently, sensitivity to the public mood and public taste can influence the reporting of news (Bromley 1994; Devereux 2003; Neidhardt, 1993; Reah 2002; Palmer 1998).

In contrast to the extensive and generalised literature on media education, focused research which relates to teaching and learning about science news in the classroom is limited. Studies which are available fall into two categories: firstly, those focusing on young people and their perceptions and understandings of issues related to science-based news reports (for example, Hilkia and Mantzouridis 2005; Korpan, Norris and Phillips 2000; Korpan, Bisanz, Bisanz and Snyder 1999; Korpan, Bisanz, Bisanz and Henderson 1997; Norris, Phillips and Korpan 2003; Norris and Phillips 1994; Phillips and Norris 1999; Ratcliffe and Grace, 2003; Ratcliffe 1999;) and, secondly, those focusing on teachers and their perceptions and use of science-based news reports (for example, Jarman and McClune 2007, 2005, 2004, 2003; Kachan, Guilbert and Bisanz 2006; McClune & Jarman 2001, 2000).

Research which focused on students' perceptions of and response to science-based news would suggest that science education does not adequately prepare young people to engage critically with science in the media. Phillips and Norris (1999) assess criticality by the extent to which 'judgements about text are warranted on the basis of reason'. In their study involving students nearing the completion of high school they noted that in response to science-based media stories only a minority of students adopted critical positions. They observed that students most commonly overestimate the certainty of statements in news reports. This reported lack of criticality is mirrored in other studies and might suggest that students are vulnerable to the influences of persuasive journalists and others; hence the need to promote critical thinking about science-based media.

Research which focused on teachers' perception and use of science-based news suggests that, while these resources are capitalised upon in the classroom, the approach could best be

characterised as casual and unsystematic (Jarman & McClune 2002; Kachan et al 2006). These investigations reported that the role of topical news items in curriculum enhancement, that is in promoting students' interest in a topic and in contextualising, reinforcing and extending class-work was well recognised. However, they uncovered little evidence of news-based activities integrated into programmes of study in such a way as to develop criticality among all students throughout compulsory schooling. The Jarman and McClune (2002) study of practice in Northern Ireland secondary science departments indicated that such an approach to newspapers was adopted most often, sometimes exclusively, with older, more able students. The Kachan et al (2006) study in Canadian schools found that news items were used to teach students how to evaluate media reports, but only in those courses with examinations that included questions based on news texts. Many young people, therefore, were not granted the opportunity to cultivate the knowledge and skill necessary to engage critically with science in the news.

Teachers' practice might suggest that they view news-based work as having discrete levels. The use of news as a means of curriculum enhancement is acknowledged as appropriate for all however its use as a means for promoting skills of critical evaluation is considered more challenging. In the absence of a developmental model for advancing such higher-level skills, teachers perceive many of their students (and perhaps themselves) as ill equipped to address the issues.

To date, there has been only limited enquiry into the use of newspapers in secondary science teaching. As a result guidance and resources, which directly support evidence-based practice in the classroom in this regard, is wanting. Consequently, while the case for inclusion of media-based sources of science may be acknowledged, the practical implications of this for curriculum planning and pedagogy in science have yet to be fully explored. Furthermore, there

are potentially a number of disciplines which could make a valuable input to the science /media / classroom debate. These have yet to be adequately exploited.

These observations have implications for the standing of science-based news work within the curriculum and for the development of resources and teaching strategies. They are especially pertinent given the curriculum revisions in the UK and more generally the interest in this aspect of scientific literacy which is increasingly reflected in science standards from around the world. In particular they would suggest that the drawing up of a set of justifiable statements of instructional intentions aimed at promoting among young people a capability to respond critically to science in the news would be timely. An absence of clear statements of what people need to know and be able to do in order to engage critically with science in the news hinders the development of systematic teaching programmes which might emerge from a well founded framework of desirable learning intentions.

The context of this study is the transition which must take place when broad educational aims and curricular goals are translated into educational practice.

The purpose, ultimately, is to enable teachers to design relevant programmes of study, to provide useful learning experiences which ensure continuity and progression for students and to provide schemes of assessment which are effective in evaluating their learning in an aspect of the science curriculum which is increasingly being regarded as important. It is specifically the first of these that is the focus of this paper. The research aims to advance the pedagogy of media-related, and specifically news-related, science instruction. This study gives voice to experts from a number of fields of enquiry which relate to the engagement with science in the media. It sought to contribute to an understanding of the conceptual basis of classroom practice intended to promote critical engagement with science-based newspaper reports. It is based on the premise that, by drawing on expertise distributed in different disciplines, a

comprehensive list of key elements which underpin critical engagement with science in the news can be identified. These elements can then be expressed as desirable learning intentions, thereby providing an evidence-based rationale for purposeful media-related practice in the classroom. The question this research sought to answer was what are the elements of knowledge, skills and attitude which underpin critical reading of science-based news reports?

Methodology

Interviews with twenty-six specialists who have an interest and expertise in the area of science in the media generated the data set for this study. The structure of the panel recognises what Hargreaves and Ferguson (2000: 4) described as the need for a 'pan-disciplinary insight into the way the media works for science'. Participants from the United Kingdom, Ireland, the United States and Canada, provided both an interdisciplinary and an international perspective on the topic. They were asked for, and agreed to, the limited commitment of a face-to-face interview and these took place over an extended time period. Although comprehensive this approach presented some logistic challenges, consequently, informants gave their opinions independently and no subsequent cross discussion was planned. Table 1. shows the subject related make up of the panel.

(Insert Table 1. about here)

The panel had a mix of science and media educators, who might be expected to share the perspective of the end users, and those reflecting both the academic interest in science communication and the community of practice, the journalists. All of the individuals were identified on the basis of their prominence in the relevant literature or by the nominations of professional and subject specific organisations such as the National Association of Science Writers and the Association of Schools of Journalism and Mass Communication. Each of the journalists had a prominent profile in the UK or Irish national daily press: 'broad sheets ',

'middle market' and 'tabloid'. The overall size of the panel was sufficient to ensure the comprehensive nature of the data. Interviews generated a variety of views on a broad range of issues with sufficient overlap and duplication to allow confidence that key themes were adequately explored. The interdisciplinary nature of the topic was reflected in the panel and inevitably categorisation according to the simple grid (Table 1) was difficult. Where the breadth of an individual's work made categorisation difficult panellists were grouped according to the major thrust of their most recent work.

Audio recordings and field notes were made during semi-structured interviews each of which typically lasted between 45 and 60 minutes. Panel members had been made aware in advance of the core interview question:

> "What knowledge, skills and attitudes (habits of mind) would be useful to people as they engage with science related articles in newspapers?"

Having posed the question, in-depth discussion allowed for the clarification of ideas and the development of responses and provided for an extensive exploration of what each panel member believed to be the core elements of knowledge, skills and attitude which underpin the capability to engage, critically, with science in the news.

Two researchers working collaboratively in order to generate coding categories for analysis of the responses reviewed interview data. Initially coding categories were generated iteratively using a small sample of data. Subsequently a 20% sample of the interview data was selected; each interview was examined and coded independently by the researchers. A moderating process where coding discrepancies were discussed and resolved followed this coding. Finally the coding procedures were cross-checked to ensure consistency of practice. When full agreement was reached the remaining interviews were analysed using the agreed categories.

This analysis of the interview transcripts identified a large number of statements describing the characteristics and capabilities associated with responding critically to science in the news.

Each statement represented an item of knowledge, skill or attitude. A number of the statements had common characteristics with the same core idea expressed by many interviewees. Some of these were alternative, but complementary, statements representing their different perspectives and frames of reference. However, there were no examples of views which were incompatible or mutually exclusive. Some statements described a proposition made by a minority or in some cases only one interviewee. Initially knowledge, skills and attitude headings were used to facilitate analysis, scrutiny of the data identified the need to further subdivide this simple framework to take account of the complex nature of the issues involved.

Outcomes

The study sought to identify basic elements of knowledge, skills and attitudes which underpin the capability to engage critically with science in the news. These were grouped in five categories:

- Knowledge of science
- Knowledge of writing and language
- Knowledge about news, newspapers and journalism
- Skills
- Attitudes

Using these categories as a basis for subsequent analysis, researchers identified fourteen elements which experts considered to be necessary for critical engagement with science-based news. The profile of these categories and elements is set out in Table 2.

(Insert table 2 about here)

During the course of interviews experts described the behaviour that they believed characterised critical engagement with science-based news and proposed that it is this behaviour that those promoting critical engagement should seek to engender. These elements of critical capability identified through analysis of the data along with descriptors of behaviour

and illustrations drawn from the interview records have been used to construct a profile for each of the knowledge, skills and attitude categories.

Category profile: Knowledge of Science

Experts considered that certain knowledge in relation to science is essential if a reader is to respond critically to news reports with a science component. Three interrelated elements of science knowledge emerged from analysis of the interview data;' Science ideas and methods of enquiry', 'Science practice in research communities' and 'The nature of the scientific enterprise'. These elements along with their associated interviewee statements in the form of learning intentions are set out in Table 3.

(Insert Table 3. about here)

It was widely agreed that to engage with science in the news students need 'some understanding of both science ideas and science as a process'. It was suggested, for example, that individuals should 'have enough science knowledge to get into the story', 'have enough of a science base to sustain them through the article' and 'be comfortable with science terminology even if there is no deep understanding'.

Underlying these statements is the idea that a basic grounding in science is the key to understanding. Hence, coping with science vocabulary, interpreting graphs, applying subject knowledge are all covered by the term 'background knowledge' which many experts used. Proficiency in these areas is what makes the difference between the ability to extract information from a text and the capability to comprehend what the text is saying. As one respondent suggested:

> 'In relation to background knowledge, comprehending what is in the text is far different from what I call being able to locate information in the text. With knowledge of syntax

and word knowledge you can identify if something is a reason for something even if you don't understand the reason. So background knowledge is crucial'.

Interestingly, journalists suggested that a well-written article would give the reader all the information that he or she needed; many experts, on the other hand, believed some background science knowledge was necessary. As one respondent put it:

'Students need to have some basic science knowledge to engage with science in the media, but probably not a lot'.

While recognising the need for some foundational science knowledge, experts were careful to avoid over-emphasising this element and thereby consigning media related work to older more able students specialising in the sciences. When referring to methods of enquiry respondents pointed to the importance of students having first hand high quality experiences of experimental work in which matters such as reliability and validity are stressed. They should know from their own experience about the role of experimental work in developing scientific knowledge and be able to make observations about a fair test or consider the impact on a study of sample size.

Analysis of the experts' views would suggest that to engage critically with science-based news students should also appreciate how science is conducted within scientific communities. There was much emphasis, for example, on the working practices of scientists and in particular the ways in which knowledge is constructed and communicated. It was suggested that students should have some knowledge of the role played by conference presentations, peer reviewed papers in journals and review articles in establishing knowledge. Issues relating to the credibility of sources were also raised. It was suggested that science in the news is dominated by relatively few easy to use sources. Experts drew attention to 'a hierarchy of credibility' and the tendency for newspapers to rely on official sources. It was suggested that students should judge the authority of a source as part of weighing the evidence. However, while it was thought

that students should recognise established sources of authority when evaluating the currency of the information there was a note of warning. It was suggested that:

> 'You would not want them [students] to merely equate degree of authority with the worth of an argument. Indeed this is half the point of science - there gloriously are times when the authorities are not right'.

Furthermore, in describing the scientific community as a 'first past the post' organisation one respondent highlighted how working to deadlines is a feature even within the scientific community. Consequently the critical reader needs to be aware that from time to time science which has a media profile may be satisfying a number of different agendas among which may be the desire for prominence for the individual, the research team or the institution.

In addition it was suggested that readers need an understanding of how science is funded and some drew attention to possible conflicts of interest. Their concern was that the reporting of science would be influenced by its increasingly commercial links.

> 'We would want to develop an understanding that there are interests that influence scientists whether it is that they want the publicity for promotion, or that they are publishing something in order to support their funding organisation'.

However, in commenting on possible 'conflict of interest' they often did so in cautionary tones. For example when referring to the funding issue one expert noted:

> 'As scientists become more dependent on external funding for their research this [funding] increasingly becomes an issue. On the other hand, just because someone is funded by industry does not mean that his or her science is poor. One would want readers to be aware a little more of the nuances of conflicts of interest'.

Those interviewed suggested that students should grasp some of the issues arising from the nature of science itself. In relation to this element it was proposed that it is important to know what questions science / scientists can answer and what questions they cannot answer.

> 'People should know that there are certain questions where at present we cannot yet give a definitive answer - that is they should know about the characteristics of science-in-the-making'.

In drawing attention to uncertainty associated with 'science-in-the-making', experts discussed the implications of this for the application of and news reporting around science and technology in society. In particular, they stressed for an understanding of elementary statistics, of chance and coincidence, of cause and effect and, especially, of the perception and assessment of risk.

Category profile: Knowledge about writing and language

Experts considered that certain knowledge in relation to writing and language is essential if a reader is to respond critically to news reports with a science component. Three interrelated elements of writing and language knowledge emerged from an analysis of the interview data: 'Format and function of news text', 'Message presentation' and 'Interpretation of text'. These elements along with their associated interviewee statements in the form of learning intentions are set out in Table 4. Though largely untried in the science education context many of these ideas will be familiar to teachers in other disciplines in particular media studies and English.

(Insert Table 4. about here)

Members of the expert panel contended that young people should have an appreciation of the place of the science news reporting within the range of science writing genres. As one respondent commented:

> 'Students should be aware that there are different types of text for example; textbooks are designed to restrict interpretive flexibility. Scientific writing in general is meant to do that. Some writing is meant to be evocative…. Newspaper briefs are somewhere in between these two. They are not poetry but they are not written with the degree of precision and exactness of a scientific paper'.

Two issues relating to newspapers emerged. Firstly, the need for specific instruction with respect to the format of science-based media texts, it was noted that:

> 'If no-one has ever talked to you about what you should be aware of in this particular genre then you may approach it in the same way as you approach anything else you read not recognising that there are differences in the language, the texture, the context, the amount of information…'

Secondly, the need for insight into the function of media texts was noted. It was suggested that to equip the critical reader to ask pertinent questions they must recognise that in the area of science reporting newspaper articles are often derived from texts used within a scientific community and are 'a window on a whole other community of practice '. One respondent noted:

> 'Media texts can alert people to things but such reports are limited because news stories, which are usually brief, cannot be complete'.

Experts suggested that, when reading text of any sort, and particularly text dealing with science-related issues in society, individuals should be able to recognise those literary devices writers may use to sway their audience. Clearly, how the narrative is constructed may influence opinion by including arguments in support of a position but not against. How writers use language, however, is also of importance and knowledge of the potency of emotive language and an ability to identify such was viewed as a key aspect of critical engagement with text.

The critical reader needs to be alert to the characteristic features of news text. Experts held the view that people should have an awareness of the language of media texts - this is not simply words, but layout, use of images, relationship between image and text. Images can be manipulated to advance the viewpoint of the writer. By the same token statistics can be presented so as to favour one interpretation over another. In addition it was suggested that people needed to know that the message is tailored for a particular audience, hence students should be aware of the audience for media texts – who is being addressed, what assumptions

are being made about the readership. They also considered that people need to recognise the techniques used to engage the readers' attention, for example, the use of quotes to bring humanity personality and in some cases authority to the story. An interesting distinction between story making and factual or scientific writing was made by one respondent. This further emphasises the importance of the presentational aspect of science in the news.

> 'Remember, newspapers are trying to make a story; they are not presenting results from a science study. They are writing a story about a science study and trying to get you to read it and trying to get you interested in it'

Experts considered that students seeking to access science in the media needed to reflect on the possible meanings of the text in the newspaper. Many specialists focused on the active role of the reader and how people make meaning in response to the text. They suggested that students should be aware that meaning is not necessarily obvious or indeed the same for every reader. The views of a number of interviewees were expressed by one respondent who noted:

> 'The reader should recognise that text is a human construction – a product. The meaning is not just going to jump out - reading takes effort. Meaning comes at lots of different levels. The reader needs a multifaceted view of what text is and needs to be able to read at different levels. What does it say on the surface? What is implied, presupposed? What is not said?'

The underlying idea is that 'people read news stories according to their viewpoint' so, amongst individuals, their different experiences and backgrounds may lead them to different interpretations. Indeed, as individuals we cannot be sure that we will be consistent in the meaning we may take from the same text at different times or under different circumstances. Significantly one expert pointed out.

> 'The reader is important. What an individual takes away from a news story depends on his / her belief system. We have stronger personal belief systems built up in relation to certain issues than others'.

Specifically she pointed out that while, in relation for example to political reporting viewpoints tend to be firmly established and so relatively immune to influence by opposing arguments, in the case of many socio-scientific concerns this is less so. Hence, we may be more susceptible to being swayed by such science-related reporting. Experts suggested that when reading news text students should 'be aware of limiting clauses in the story' that is, they should recognise the existence and significance of any qualifications or conditions that circumscribe its conclusions. Finally the particular challenges of interpreting written text were noted. It was suggested that:

> 'People need to know that text is not speech written down. Speech has gesture and tone and people attend to these. Text has punctuation etc. And this makes different interpretational demands'.

Category profile: Knowledge about news, newspapers and journalism

Experts considered that certain knowledge in relation to news, newspapers and journalism is essential if a reader is to respond critically to news reports with a science component. Three interrelated elements of media knowledge emerged from analysis of the interview data; 'Journalistic practices', the 'Nature of news' and the 'Characteristics of newspaper reports'. These elements along with their associated interviewee statements in the form of learning intentions are set out in Table 5. These learning outcomes though identified here in relation to science-based news are also documented in the media education literature.

(Insert Table 5. about here)

Experts indicated that the working practices of journalists and their institutions are important factors influencing the production and presentation of news. This view was shared by many interviewees and is illustrated in the comment:

> 'The reader should know something about journalistic practice – the modus operandi and the reward structure. It seems to me that it is important – it is crucial as it has a role in forming what appears in print'.

In particular a number of experts drew attention to the importance of readers knowing something of the obstacles (for example, constraints of time, limited access to specialist knowledge, word limits etc.) facing those writing about science in the news. Hence one respondent noted:

> 'It is helpful [for the reader] to know something about the process, the 'journey', by which a science story moves from the lab to the newspaper'.

Perhaps unexpectedly journalists included among the obstacles their 'need to get published'. It was pointed out that one consequence of this is the scarcity of good investigative journalism in science since the time needed to investigate a potential story in-depth will mean that the journalist (and the editor) will have to accept several days without her or his name in the paper. In addition to the constraints, which are a feature of all news reporting, journalists writing science-based news, stories often face the further challenge presented by their lack of subject knowledge since few journalists have specialist science background. Indeed it is important for the reader to take note of the journalist's credentials in the 'by-line' for the article. News writers often seek access to specialist knowledge and expert opinion. As noted, they do so not solely for information but in science-based stories it was observed that 'journalists use quotes to bring humanity and also authority to the story'. However, readers need to be aware that journalists may 'tidy up their quotes' as one respondent commented:

> 'It is helpful to know that the notion of 'quotation' is quite fluid. The importance of a quote is not that it is sacrosanct, but that it represents a point of view'.

Finally, experts also held the view that knowledge of journalistic practice would be incomplete if it did not alert the reader to the importance of some of the consequences of the editing process in the newsroom. These include the writing of headlines, selection of graphics and late changes to the space available for and prominence given to a particular story.

Experts believe that to enable individuals to respond critically to science in the news they should have knowledge of the nature of news. They drew attention to the purpose of news reporting, and to the importance of the reader understanding this. The intention, it was pointed out, was not solely for information-giving though this is certainly one object. Newspapers also aim to entertain the reader, to influence their opinion and, crucially, to make a profit. All news is a construction which is influenced by the journalist, and the organisational environment in which he or she works. The journalists 'background', 'working practice' and 'world view' were all considered to influence the news. A key theme in the responses of those interviewed was the need to be aware that all messages have embedded values which shape the presentation and reception of the text. Readers therefore need to be equipped to ask relevant questions:

> 'What is the ideology behind the text, how does this speak to particular interests, what view of the world is being portrayed?'

News organisations and news workers have agendas and all news is presented from certain political and ethical viewpoints. Some newspapers take – and retain – a particular editorial position on a particular socio-scientific issue. It is valuable for readers to be able to discern this. Interestingly, it was suggested that students must appreciate that embedded values were equally common in all areas of the news media and are not limited to the tabloid press. The 'editorial position' and the 'community in which the newspaper is located' were also considered

to be influential. Indeed it was pointed out that, globalisation and multi-nationals notwithstanding, often newspapers are 'creatures of their communities'. The complexity of these issues and the consequent challenge for those seeking to incorporate them into a teaching programme was also acknowledged. One respondent noted:

> 'An important issue is the political commitment of the newspaper and how that affects its reporting of science. This is incredibly complex and difficult to address in the school setting, but it is also extremely crucial to the ways in which newspapers cover issues'.

Also important in understanding the nature of news, is the idea of 'newsworthiness'. For a subject to be newsworthy it must conform to certain well understood, albeit tacit 'news-values'. Many respondents were keen to point out that:

> 'Newsworthiness is an important issue. Journalist's work is governed by this. A sense of drama and conflict contribute to the newsworthiness of a story'.

Newspaper reports have a number of characteristic features and experts drew attention to the ways in which different elements of the news story may work separately or together to influence the reader. They suggested that to engage critically with science news the reader should be alert to the intended role and possible impact of these elements. Almost all respondents commented on the headline and the importance of recognising 'how it works'. In particular, two features of the headline were highlighted. Firstly its purpose; the headline is written to attract attention. Secondly, that its composition is not the responsibility of the journalist who wrote the accompanying story,

> 'Newspaper briefs regarding science have an information dimension but they are also there to be catchy. Sometimes provocative… and frequently misleading (in the use of headlines) we need to be aware of this'.

Newspaper articles have a unique structure and differ from other forms of text which people, particularly young people, commonly read. It was suggested that the critical reader needs to adjust to this 'inverted pyramid' style (where key points are presented in the opening paragraphs) which can distort the narrative and give prominence to some story elements which, from the science perspective, may be less important.

> 'It is noteworthy that the narrative convention adopted in newspapers is difficult to read. The newspaper is not a chronological account and the conclusion is not at the end. Rather like a soap opera, newspapers have a special way of saying things'.

In addition, news reports may not provide the reader with sufficient information to form a judgement on the story. It was noted that 'Journalists communicate main points, not details' so readers should learn to 'consult the media but not seek too much from it'.

Science-based stories often include the voice of the scientists whose work is described. Other individuals who are perceived to have relevant expertise may also be invited to comment. However, respondents suggested that the critical reader should be alert to ask certain questions to enable him or her not only to 'judge the authority of the source' but also to consider possible motivation. Important questions were considered to be:

> 'Who is 'speaking' and what is their purpose, that is, who produced or sponsored the message'?

It was also deemed important for the reader to be aware of how the expert voices were used. News reports often include opposing voices. One respondent suggested that it is important to consider what sources the journalist is employing? Why are some sources quoted early in an article and why are some sources quoted late in an article? Presenting the views of different scientists often implies impartiality in a story. This issue was raised by several experts who were concerned about the 'apparent balance' in articles where the story may represent both sides of the argument but not the weight of argument on each side. This view of balance can

be superficial and there are pitfalls for the uncritical reader. The challenges for the reader and the consequences for science reporting were noted:

> 'Newspapers in their efforts to achieve balance will pit one expert against another expert. This is part of the practice of journalists. How do readers evaluate the 'duelling scientists'? How do we know which one speaks better truth than the other? The reader needs to ask; has enough background about this scientist been provided? What sort of background information would be needed? Is this person considered the extreme by 99% of other scientists in the field? Or, is this person an industry scientist or a government scientist'?

Some, though not all respondents, commented on the need to consider the accuracy of science-based news reports. Science journalism was considered to be generally of a high standard. Errors in reporting do occur though it was argued less so than is commonly thought. Many respondents were keen to avoid either a too simplistic or an over critical approach while promoting a healthy scepticism. The cliché 'don't believe everything you read' was voiced.

Category profile: Skills

Experts considered that certain skills were essential if a news reader is to respond critically to news reports with a science component. Two interrelated skill elements emerged from analysis of the interview data; 'Reading' and 'Thinking and enquiry'. These elements along with their associated interviewee statements in the form of learning intentions are set out in Table 6.

(Insert Table 6. about here)

Many experts made reference to reading skills almost in passing although some, notably those from education, recognised that a pupil's basic reading skill could not be taken for granted. In relation to more advanced reading skills, it was recognized that different approaches are

needed for different types of writing found in the newspaper and it would be rash to assume that the individual has the same level of reading skill in different genres. Respondents provided some insight into the challenges which the text-based tasks can present for students:

> 'When children learn to read almost all the text is narrative. We make the assumption that if they can read this form of text they can read all other forms but different genres make different demands. A large proportion of text in news briefs is argumentation that is offering reasons to support conclusions'.

In addition, some experts used the term 'critical reading' to refer, quite specifically, to the need for higher level reading which considered for example, the 'reliability of the science, context of the story, and motive of the journalist'. The critical reader is seen as engaging with the text and, rather than passively accepting what is offered, interrogating it, testing it and identifying its shortcomings in order to respond to it appropriately. It was suggested that:

> 'Young people would need the ability to read critically answering questions like: Who wrote the article? What do I know about the methodology of a study being reported? Who is the source of information? Newspapers are great for developing these skills and capacities'.

The last comment is significant in that it not only highlights the need for critical reading skills but also affirms that newspapers can be used to promote the development of these skills.

Thinking about what is read was a core theme in the interview data. At one level this could be to encourage students to compare what they read with their existing science knowledge. The importance of thinking was ardently expressed by one respondent who suggested that:

> 'Kids need to be taught to think. To be taught that they have the liberty to question, to evaluate, to look for agendas, to not believe. This is most important. This is what you prepare citizens for. I don't think the ability to ask critical questions about science or

about newspaper reports is a small skill. I think it's probably the most important thing you could teach someone'.

Notably it was suggested that media-based activities might be designed to promote thinking skills. Many experts highlighted the need for what they called 'critical thinking' which requires some effort on the part of the reader. It was suggested that this way of approaching science in the news is something that the student must be encouraged to work at.

'When we read media messages, our first impulse is to believe them and only subsequently to pull back. This is our default way of seeing the world. So the development of critical thinking is important'.

When discussing 'critical thinking' others referred to 'giving a good set of reasons as to whether or not they agreed with the conclusions reached by the writer' and the ability 'make judgements', and to 'filter out the things they don't need to know'.

Then again a number of respondents suggested that 'reading between the lines' was a critical thinking skill. This was also linked to the need for further enquiry.

'An important skill is being able to identify 'What is missing in this story that I would need to know in order to be able to make an informed judgement?' and 'How could I seek out additional information'. Multiple sources is an important idea – and the credibility of that source'.

Enquiry skills include evaluation of sources and finding additional relevant information. This raises the expectation that critical engagement with science in the news will at times involve exploration of other media and additional sources. As one respondent noted, 'enquiry skills' denotes 'the ability to take things further'.

The three way presentation of this category as reading, thinking and enquiry reduces the risk of oversimplification and the array of skills related to critical engagement with science in the news cited by one respondent illustrates the complexity of the task.

> 'Part of what we need to teach people consuming newspapers is a whole range of skills, for example the valuing of the scientist's or the journalist's reputation, the need to make credibility judgements, the need for inductive reasoning, bringing personal judgement to bear, reaching generalisations, being aware of the scope of the data'.

Category profile: Attitudes

Finally, experts considered that there were certain habits of mind that would prepare the reader to adopt a critical stance to news reports with a science component. Three interrelated attitudinal elements emerged from analysis of the interview data; 'Curiosity', 'Self-confidence' and 'Expectation'. These elements along with their associated interviewee statements in the form of learning intentions are set out in Table 7.

(Insert Table 7. About here)

The attitudes which experts believed to be desirable were often related to the type of actions they would engender. Consequently, there is some overlap of terminology between the elements of attitudes and skills, however for clarity they are considered separately since to have a questioning attitude and to be able to ask effective questions are not one and the same.

An element of curiosity is needed if a reader, browsing a newspaper, is to be stirred to stop at a science story in the first instance. However, experts had a more specific view of curiosity in which an individual is often characterized by his or her inclination to ask questions in relation to the text. Hence, they suggested that curiosity might be evident when people 'question the reliability of the sources', ask if 'the work had been peer reviewed', consider 'if the reported science is controversial or consensual' and question 'how the research was funded'. Many linked curiosity with a 'healthy scepticism'. They believe that this sceptical attitude would also help people to ask appropriate questions. 'Is it plausible? Is the story exaggerated? Does it

take account of different points of view? Why is the story written? There was also the recognition that curiosity which leads to critical engagement is also accompanied by 'motivation' and a 'willingness to persevere'.

Experts believed that individuals need to be confident as they approach news reports with a science component since a lack of self-assurance would hinder their capacity for critical engagement. Confidence, some suggested, however, should be based on knowledge:

> 'Students need confidence which comes from an expectation that their science knowledge will enable them to get into the article'.

These respondents highlighted two aspects of the links between knowledge and confidence. Knowledge helps the student to view science in the news from the perspective of the 'insider'. When students have sufficient knowledge to be aware of at least some of their limitations they may be more confident in what they do know. However, experts were aware that both misplaced confidence and unwarranted scepticism could hinder critical engagement with news-based science hence it was suggested:

> 'A good science education allows people to be confident but also to know the limits of their knowledge'.
>
> 'We wish to develop criticality, not withering scepticism'.

Members of the expert panel recognised that the temperament and outlook of the reader influences her or his level of engagement.

> 'The disposition of the reader i.e. passive, open minded, critical, influences or determines the response which people make to the text'.

The critical reader is seen as having level of expectation towards science which was described in terms of 'ownership of science', 'interest in science' and a 'positive, though critical, view of science as part of life and culture'. Experts identified two strands in relation to ownership. They

held the view that for students to respond critically to science in the media they need, in the first instance, to accept science as a source of trustworthy knowledge about the natural world. This is not to underestimate or ignore the limitations of science or the challenges of obtaining valid and reliable data about that world. In addition, students need an attitude towards science which is inclusive. The idea of ownership of science as an important aspect of their culture was advanced by several interviewees:

> 'We hope that people will form the view that science is part of their lives and culture – an inclusion of science in their cultural landscape'.

Expectant readers value the contribution of good science reporting to developing informed opinion and are willing to interrogate science reporting.

Unlike knowledge and skills, attitudes are difficult to quantify and perhaps even more difficult to promote. Many experts acknowledged the complex and difficult nature of the task.

Nonetheless, critical engagement with science in the media is, in the view of the specialist group, highly dependent on attitudes towards both science and the media. These are engendered in part by teaching but also by influences in society as a whole.

Summary, Discussion and Conclusion

Without some science knowledge access to news reports with a science component will be limited. However, in order to respond critically to science in the news the reader also needs to know something about the nature of science, the process of science enquiry and how science is practised in scientific communities.

Adopting a critical stance towards science in the news requires the reader to have knowledge of language use and writing genres in order to be aware of the influence of different writing styles In addition, the reader seeking to access science in the news should know that there may be multiple meanings attached to the news story and that both the writer and the reader

contribute to meaning-making in relation to the text. Media education texts refer to meaning as being negotiated. They recognise that individuals draw on their own experiences and values in response to media messages.

Knowledge of journalistic practice and newspaper codes and conventions empowers the critical reader who should be aware that the news report is 'constructed' by the journalist or journalistic team, often working under constraints of time, article length and sometimes with limited background knowledge and even the choice story will have been influenced by news values. Journalists will often only to present the main points of the story, and the appearance of a balanced argument may be misleading; Furthermore, all media messages have embedded values. The critical reader should be cautious. The primary purpose of media is not to educate, rather to inform, interpret, persuade, frequently to entertain and, crucially, to make profit for its proprietors or at least to ensure economic viability. These codes and conventions of Journalistic practice are well-recognised themes in media education. Their influence on media presentation of science sets it apart from other forms of science writing. In particular the notion of news construction which is value laden stands in stark contrast to the majority of science writing which is intended to restrict multiple readings of the text.

Reading, thinking and enquiry have been identified as skills that are needed if people are to approach news texts critically. Guides to media education often provide helpful 'critical thinking checklists' (Duncan, 1989). The critical reader needs to have the capacity to look beneath the surface and beyond the text to question in a positive – constructive - way. Hence, enquiry skills that empower the reader to subject science news reports to close scrutiny, identifying important facts, interrogating the text, evaluating the authority of both writers and informants, and, if necessary, looking for confirmation from other sources are critical.

An enquiry model of learning that seeks to foster 'intellectual curiosity' and 'critical autonomy' is often promoted in media education. This study outlines the importance of similar attitudes in

promoting critical engagement with science in the media, In addition it recognises the importance of promoting the view that science is part of life and culture and that people should expect to engage purposefully with it and so gain trustworthy insights into the natural world.

Recent curricular initiatives in the UK and elsewhere encourage science teachers to engage with science in the media. However, to date there is limited data on which to base decisions about curricular planning and provision hence many judgements that are currently being made are intuitive. Similarly there is no opportunity to advance evidence-based practice in relation to classroom teaching with respect to this matter. Based on the analysis of the interview data we draw a number of conclusions which address these issues.

Firstly in relation to elements of knowledge, skills and attitudes which might inform curricular provision we conclude that:

- It is possible to identify essential elements of knowledge, skill and attitude that could be justifiably considered to contribute to an individual's capability to engage critically with science reports in the newspaper and that the nature of these is such that they could be incorporated within existing or redesigned programmes of study.
- Some, though not all, of these elements currently exist within programmes of study across a number of curricular areas, at least in the UK. As a result it is now possible to envisage a coherent cross-curricular approach to this theme.

Secondly in relation to learning intentions we conclude that:

- The individual's critical reading capability will be advanced by addressing the specific learning intentions associated with the elements of knowledge, skills and attitude within programmes of study.
- The achievement of critical capability at any level is dependant on the capacity to integrate the learning in different curricular areas and demonstrate a range of

competencies appropriate to the context. It is reasonable to foresee a spectrum of critical capability dependant on the age, ability and experience of the individual.

- Progress in the development of critical capability may be charted using criteria derived from the learning intentions. This framework, then, has the potential to inform assessment in this regard.

The importance of this study is that it seeks to map a path from the aspirational statements in curricular documentation to desirable learning intentions which might support effective pedagogy with respect to critical reading of science in the media. It is anticipated that the framework of core elements and learning intentions may act as a guide for curriculum planning and inform the subsequent development of teaching strategy in this area.

The framework may have a number of uses. In addition to its role as a guide for curricular planning it might form the basis for the examination and subsequent coordination of curricular provision with respect to this topic. However, it should be noted with caution that the identification and even planned coordination of curricular opportunities may not prevent pupils experience falling disappointingly short of the desired outcomes and curricular expectations since this limited approach does not take account of the need for teacher development and the challenges of cross disciplinary working.

The outcomes of this study emphasise the multidisciplinary nature of the topic and this adds weight to the case made by media educators for collaborative working in this area. It could be anticipated, however, that the involvement of multiple subject specialists may present some barriers to implementation, not least the challenge of cross-disciplinary working. Science teachers will find some of the elements unfamiliar and will be uncomfortable with the prospect of addressing these in the science classroom. Teachers from other disciplines will be equally ill at ease with science related aspects of the topic. However, it is unlikely that all the elements

would be the responsibility of only one specialist. Indeed pupils may currently address these issues in a number of different curricular areas. Nevertheless, it is doubtful that most students would be able to integrate the relevant learning from their different subject specific experiences without appropriate support. Similarly it is doubtful that teachers, other than science specialists, would share an equal awareness of and a concern to promote students engagement with science in the media. Hence the desirability for a role in promoting co-ordinated and collaborative approaches. A role which in most instances is likely to fall to the science teacher. The subsequent burden this places on science teachers is likely to require ongoing professional development that will need to be accompanied by similar interventions in initial teacher education.

The identification of the basic elements of 'critical reading' in relation to science news text in a manner capable of informing planning and pedagogy is an important first stage in supporting teachers' practice as they attempt to promote this aptitude and ability amongst their students. However, more remains to be done. The framework based on the views of the expert panel will benefit from being refined by teachers, from a range of disciplines, whose viewpoint will be influenced by the need to plan coherent programmes of study and design appropriate learning experiences based on these elements. Educational support materials are important and in particular those that exemplify the developmental nature of programmes of study demonstrating continuity and progression in this area during the period of secondary schooling will be valuable. Such programmes might acknowledge the cyclical nature of media education and go some way to challenging the tendency to reserve science-based media work for older and more able pupils. Finally there are assessment related issues which, though important, were beyond the scope of this study. The development of critical capability in relation to science-based news may be a long-term goal of science education; however teachers will want

to monitor progress which is charted through short and medium term objectives while analysing the effectiveness of specific strategies and the benefits of ongoing programmes and targeted interventions. The list of desirable outcomes may provide an appropriate starting point for creative and imaginative approaches to these challenges.

This study is important in that it provides an evidence-based framework within which to explore critical engagement with science in the print media. It presents a comprehensive and broadly based perspective on the issue. As such it should be relevant to science educators working in the classroom, those engaged in teacher education and those responsible for policy implementation.

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Table 1. Specialist panel areas of expertise

Science education	Media education* (*including science in the media specialists)	Science communication	Journalism
9	7	6	4

Table 2. Knowledge, Skills and Attitude elements of critical capability

Category	Elements in critical response to science-base news
Knowledge of science	• Science ideas and methods of enquiry
	• Science practice in research communities
	• The nature of the scientific enterprise
Knowledge of writing and language	• Format and function of news text
	• Message presentation
	• Interpretation and meaning
Knowledge about news, newspapers and journalism	• Journalistic practice
	• Nature of news
	• Characteristics news reports
Skills	• Reading
	• Thinking and Enquiry
Attitudes	• Curiosity
	• Self confidence
	• Engagement

Table 3. Knowledge of Science profile and examples of desirable learning intentions

Category	Element	Anticipated learning intentions. Students should:
Knowledge of science	Science ideas and methods of enquiry.	• have a basic understanding of scientific enquiry • know some background science, including understanding of terminology and graphical representations, related to the science-based article
	Science practice in research communities	• understand the method scientists use to gain new knowledge and be able to identify the procedures such as peer review and replication which allow people to have confidence in the way scientists work • know that science is increasingly competitive and commercial and often originates in industrial contexts • be aware of how science is funded and the possible implications of this in relation to the reporting of science
	The nature of the scientific enterprise	• understand that there are some questions which science cannot answer with certainty • be aware of the tentative and possibly contested nature of cutting edge science • recognise the concerns and interpretational challenges surrounding; 'risk and probability', 'cause and correlation' and statistics

Table 4. Knowledge of writing and language profile and examples of desirable learning intentions

Category	Element	Anticipated learning intentions. Students should:
Knowledge of writing & language	Format and function of news text	• have an understanding of the format of news text • have an understanding of the function of non-fiction news text
	Message presentation	• identify emotive and persuasive language • demonstrate an understanding of the impact of presentation and layout in newspapers • understand that both images and statistics can be manipulated to suit a purpose • be aware that journalists work with an audience in mind • know that news involves story telling
	Interpretation of text	• distinguish between fact and opinion • recognise that text can be interpreted in different ways • understand that critical reading requires the reader's active involvement to make meaning • recognise limiting clauses within the news text

Table 5. Knowledge of news, newspapers and journalism profile and examples of desirable learning intentions

Category	Element	Anticipated learning outcomes. Students should:
Knowledge of news, newspapers and journalism	Journalistic practices	• have some knowledge of journalistic practice and constraints • know how a science-based news story comes is put together • understand how journalists use of expert sources, language and images are guided by the newspapers custom and practice
	Nature of news	• understand that news is a construction • understand that all those involved in the process of news making have 'interests' • be aware that all media, including newspapers, have embedded values • be aware that to become news, stories must be newsworthy (i.e. illustrate news values)
	Characteristics of newspaper reports	• recognise the characteristics of newspaper articles and be aware of the impact these can have on the reader • know that the writer of the article may not have represented the balance or reflected the strength of all the points of view • be aware that newspapers may contain errors and some statements may be untrue - there are a number of factors (misinterpretation, simplification, sensationalism, omission), which may cause a story to become distorted in some way • recognize that most news stories are informative but that they also written to interpret, persuade, entertain and make a profit

Table 6. Skills profile and examples of desirable learning intentions

Category	Element	Anticipated learning outcomes. Students should:
Skills	Reading	• scan the text to find important information • acquire appropriate reading skills for different genres and presentation formats found in newspapers • interpret text by e.g. reading for inference and evaluating the source
	Thinking and enquiry	• compare what they read to their existing science knowledge • identify key questions to ask about the science story • give reasons to support their opinions/ conclusions • seek out additional sources of relevant information

Table 7. Attitudes profile and examples of desirable learning intentions

Category	Element	Anticipated learning outcomes. Students should display:
Attitudes	Curiosity	• enthusiasm for and interest in discovering more about science news • a questioning and enquiring attitude expecting to make judgments • appropriate scepticism towards science in the news
	Self-confidence	• confidence in their own opinion • an open mind disposition when they read a newspaper
	Expectation	• a positive and critical disposition towards science in news reports • a commitment to active, purposeful reading viewing science as trustworthy knowledge • an awareness of the pervasiveness of science in everyday life and culture • an appreciation that news articles help to develop informed opinion • a willingness to question and to influence how science affects their community and society